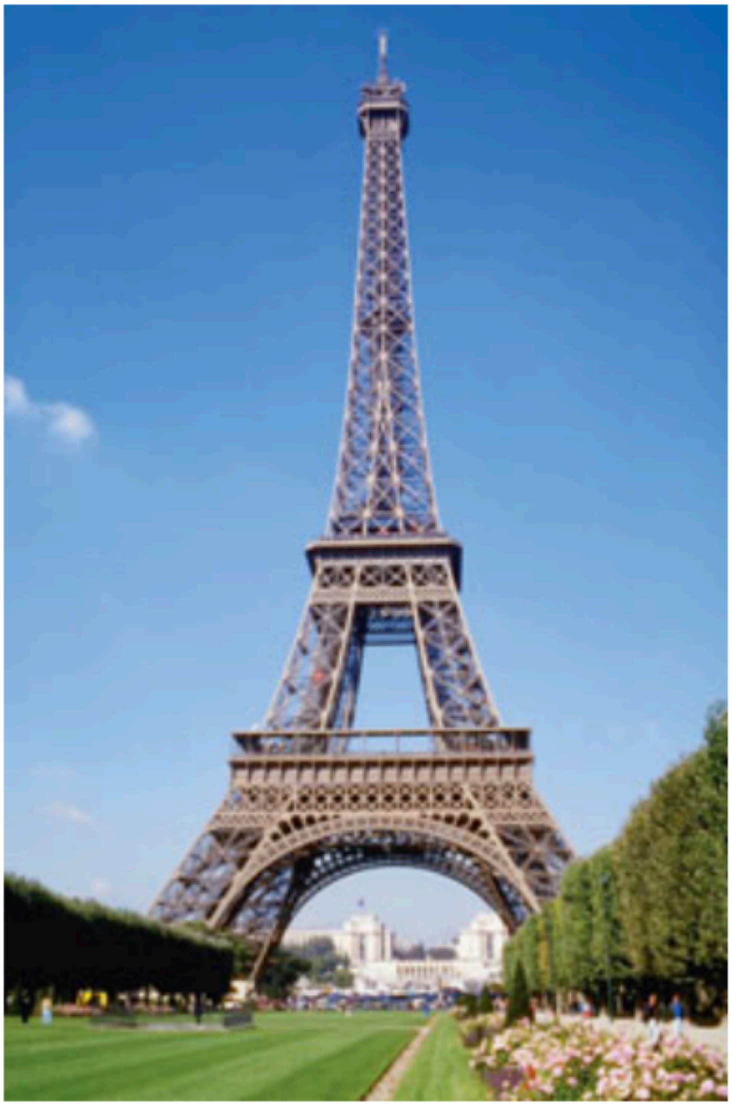
Question 1:



$L = 300m$

$\Delta T = 25 - 2 = 23°C$

$\alpha = 12 \times 10^{-6} / °C$

$\Delta L = \alpha \times L \times \Delta T$

$= 12 \times 10^{-6} \times 300 \times 23$

$= 0.0828m$

The Eiffel Tower (figure) is built of wrought iron approximately $300\,\mathrm{m}$ tall.The average temperature in January is $2^{\circ}\mathrm{C}$) and in July is $25^{\circ}\mathrm{C}$).Ignore the angles of the iron beams and treat the tower as a vertical beam. Estimate how much its height changes between January and July.

Question 2:

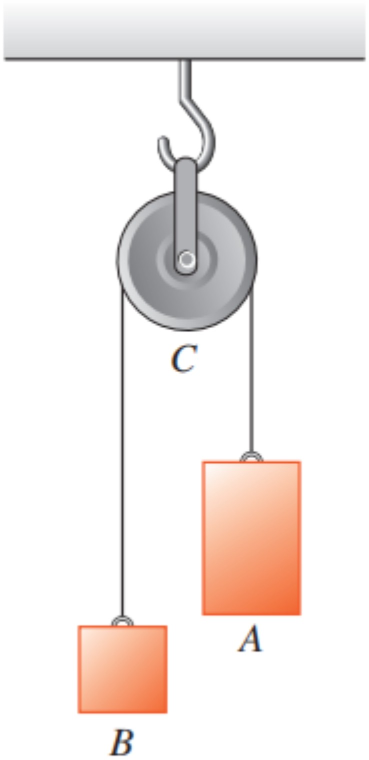


figure illustrates an Atwood's machine. if there is no slipping between the cord and the surface of the wheel. Let the masses of blocks A and B be $4.00\ \mathrm{kg}$ and $2.00\ \mathrm{kg}$, respectively, the moment of inertia of the wheel about its axis be $0.220\ \mathrm{kg}\cdot\mathrm{m}^2$, and the radius of the wheel be $0.120\ \mathrm{m}$. Find the angular acceleration of the wheel C.

B

A. $12.14\ \mathrm{rad/s}^2$

B. $7.68\ \mathrm{rad/s}^2$

C. $5.28\ \mathrm{rad/s}^2$

D. $6.68\ \mathrm{rad/s}^2$

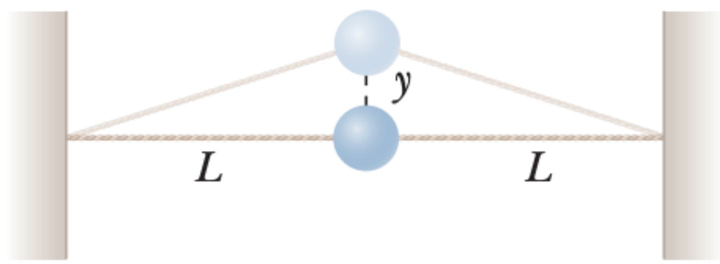
$\rho_{He} = 0.179\,kg/m^3$

$\rho_{air} = 1.2\,kg/m^3$

$L = 3\,m$

$g_{eff} = g\left(\frac{\rho_{air} - \rho_{He}}{\rho_{He}}\right) \approx 55.91\,m/s^2$

Question 3:

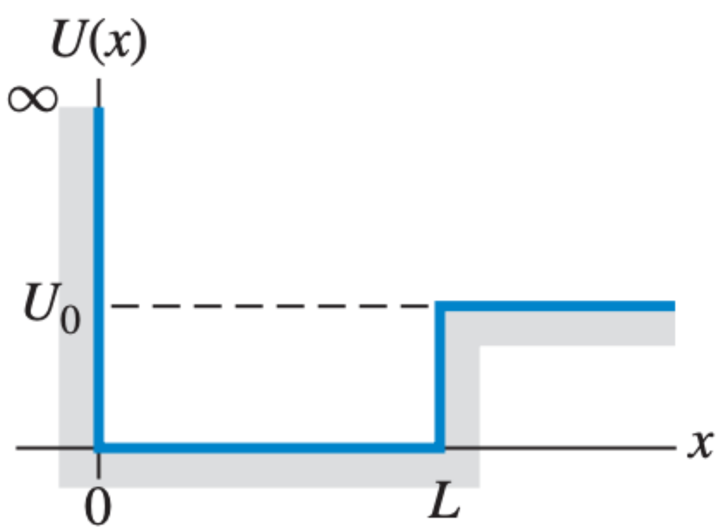


A light balloon filled with helium of density $0.179\,\mathrm{kg/m^3}$ is tied to a light string of length $L = 3.00\,\mathrm{m}$. The string is tied to the ground forming an inverted simple pendulum (figure).The balloon is displaced slightly from equilibrium as in figure and released.Take the density of air to be $1.20\,\mathrm{kg/m^3}$.Assume the air applies a buoyant force on the balloon but does not otherwise affect its motion. Determine the period of the motion.

$T = 2\pi\sqrt{\frac{L}{g_{eff}}} = 2\pi \times 0.2317$

$\approx 1.456\,s$

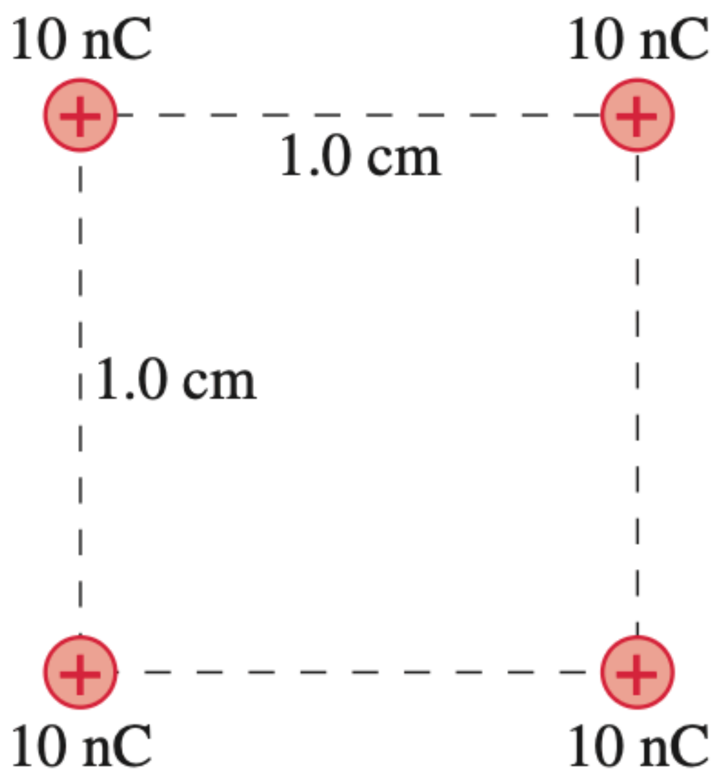
Question 4:



Consider a potential well defined as $U(x) = \infty$ for $x < 0$, $U(x) = 0$ for $0 < x < L$, and $U(x) = U_0 > 0$ for $x > L$ (figure). Consider a particle with mass m and kinetic energy $E < U_0$ that is trapped in the well.The wave function must remain finite as $x \to \infty$.And it satisfy both the Schrödinger equation and this boundary condition at infinity. What must the form of the function $\psi(x)$ for $x > L$ be?

$\psi(x) = 0$ for $x > L$

Question 5:



The four 1.0 g spheres shown in the figure are released simultaneously and allowed to move away from each other. What is the speed of each sphere when they are very far apart?

$m = 1\times10^{-3}kg$

$q = 10nC = 10\times10^{-9}C$

$d = 0.01m$

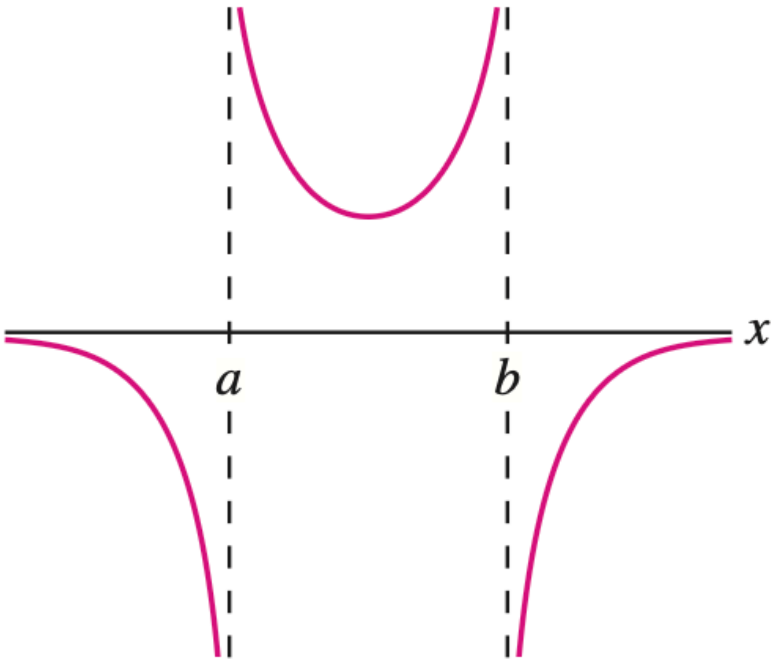
$U = 4\frac{kq^2}{d} + 2k\frac{q^2}{\sqrt{2}d} = (4+\sqrt{2})\frac{kq^2}{d}$

$U = 2mv^2 \Rightarrow v = \sqrt{\frac{U}{2m}}$

$U = (4+\sqrt{2}) \times \frac{8.99\times10^9 \times (10\times10^{-9})^2}{0.01} \approx 4.87\times10^{-4}J$

$v = \sqrt{\frac{U}{2m}} \approx 0.49m/s$

Question 6:



Two point charges q_a and q_b are located on the x-axis at $x = a$ and $x = b$. figure is a graph of E_x , the x-component of the electric field. What is the ratio $|q_a/q_b|$?

$$E \propto \frac{|q|}{r^2}$$

$$\left|\frac{q_a}{q_b}\right| = 2$$

Question 7:

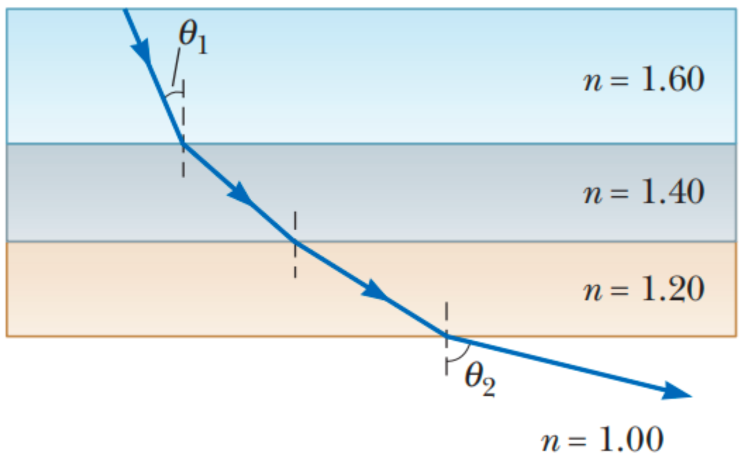


Figure shows the path of a light beam through several slabs with different indices of refraction. What the minimum incident angle θ_1 be to have total internal reflection at the surface between the medium with $n = 1.20$ and the medium with $n = 1.00$?

C

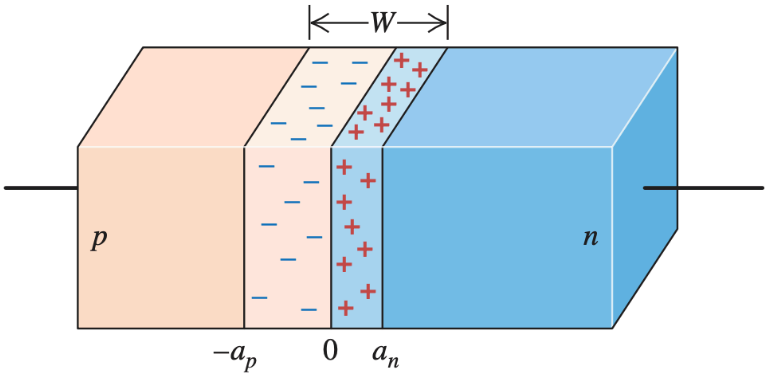
A. 30.6°

B. 26.2°

C. 38.7°

D. 36.1°

Question 8:



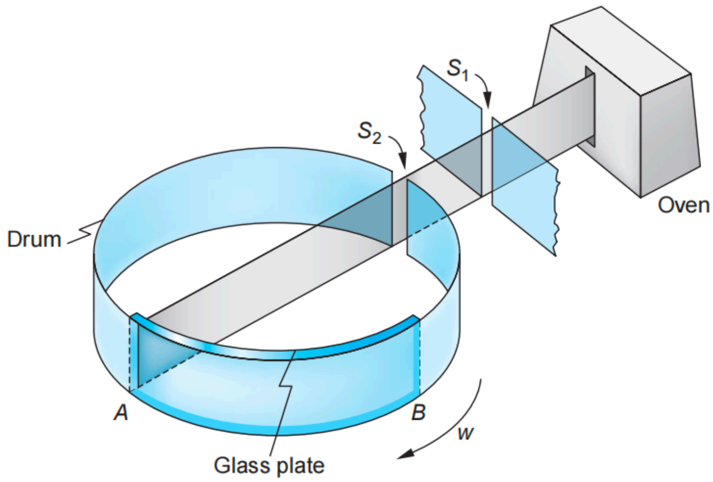
A p-n junction includes p-type silicon, with donor atom density N_D, adjacent to n-type silicon, with acceptor atom density N_A. Near the junction, free electrons from the n side have diffused into the p side while free holes from the p side have diffused into the n side, leaving a “depletion region” of width W where there are no free charge carriers. The width of the depletion region on the n side is a_n, and the width of the depletion region on the p side is a_p. Each depleted region has a constant charge density with magnitude equal to the corresponding donor atom density. Assume there is no net charge outside the depleted regions. Define an x-axis pointing from the p side toward the n side with the origin at the center of the junction. An electric field $\vec{E} = -E\hat{\imath}$ has developed in the depletion region, stabilizing the diffusion. The p side is doped with boron atoms with density $N_A = 1.00 \times 10^{16}\ cm^{-3}$. The n side is doped with arsenic atoms with density $N_D = 5.00 \times 10^{16}\ cm^{-3}$. The n side depletion depth is $a_n = 55.0\ nm$. What is the p side depletion depth a_p?

$$W = a_p + a_n$$

$$a_p = \frac{N_A}{N_D} a_n = \frac{1\times10^{16}}{5\times10^{16}} \times 55 = 11nm$$

$\therefore a_p = 11nm$

Question 9:



An early method testing Maxwell's theoretical prediction for the distribution of molecular speeds is shown in figure. In 1925 Otto Stern used a beam of Bi_2 molecules emitted from an oven at 850 K. The beam defined by slit S_1 was admitted into the interior of a rotating drum via slit S_2 in the drum wall. The identical bunches of molecules thus formed struck and adhered to a curved glass plate fixed to the interior drum wall, the fastest molecules striking near A, which was opposite S_2, the slowest near B, and the others in between depending on their speeds. The density of the molecular deposits along the glass plate was measured with a densitometer. The density (proportional to the number of molecules) plotted against distance along the glass plate (dependent on v) made possible determination of the speed distribution. If the drum is 10 cm in diameter and is rotating at 6250 rpm. Find the distance from A where molecules traveling at $\langle v\rangle$ will strike.

D

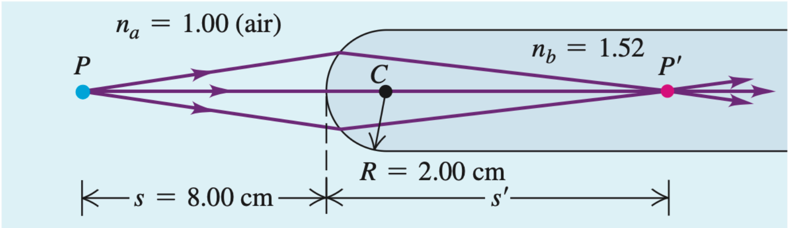
A. $0.04625\mathrm{rev}$

B. $0.05667\mathrm{rev}$

C. $0.05317\mathrm{rev}$

D. $0.05021\mathrm{rev}$

Question 10:



A cylindrical glass rod (figure) has index of refraction 1.52. It is surrounded by air. One end is ground to a hemispherical surface with radius $R = 2.00\ \mathrm{cm}$. A small object is placed on the axis of the rod, 8.00 \ \mathrm{cm} to the left of the vertex. Find the lateral magnification.

$n_a = 1$

$n_b = 1.52$

$R = 2cm$

$s = -8cm$

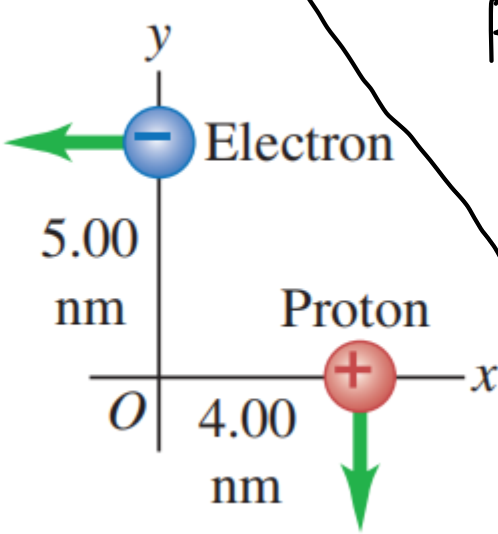
$$\frac{n_a}{s} + \frac{n_b}{s'} = \frac{n_b - n_a}{R}$$

$$\therefore s' \doteq \frac{1.52}{0.385} \approx 3.95cm$$

$$M = \frac{n_a s'}{n_b s}$$

$$M = -0.325$$

Question 11:



An electron and a proton are each moving at $735\ \mathrm{km/s}$ in perpendicular paths. At the instant when they are at the positions shown, the magnetic field the electron produces at the location of the proton.

$$B = \frac{\mu_0}{4\pi} \times \frac{q v \sin\theta}{r^2}$$

$q = -e = -1.6\times10^{-19} C$

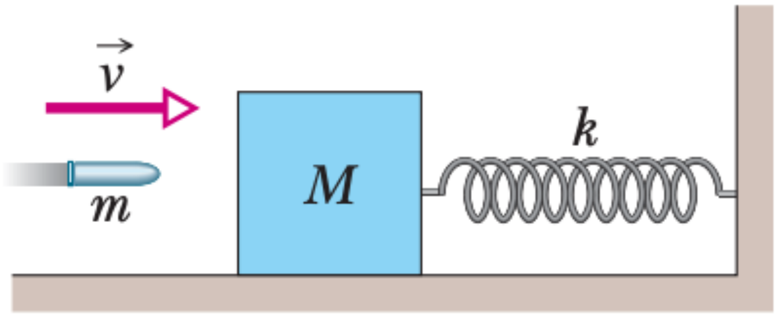
$v = 735\times10^{3} m/s$

$r = \sqrt{4^2+5^2} = \sqrt{41}\ nm \approx 6.4\times10^{-9} m$

$\frac{\mu_0}{4\pi} = 10^{-7}$

$B = 2.87\times10^{-9} T$, into the page

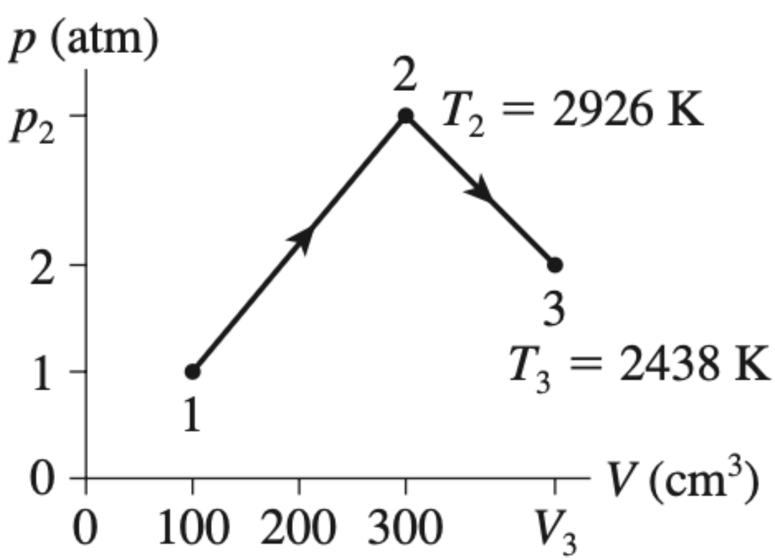
Question 12:



In figure, a block of mass $M = 5.4\ kg$, at rest on a horizontal frictionless table, is attached to a rigid support by a spring of constant $k = 6000\ N/m$. A bullet of mass $m = 9.5\ g$ and velocity $\vec{v}$ of magnitude $630\ m/s$ strikes and is embedded in the block. Assuming the compression of the spring is negligible until the bullet is embedded, determine the amplitude of the resulting simple harmonic motion.

$M = 5.4kg$
$m = 9.5\times10^{-3}kg$
$v = 630m/s$
$k = 6000N/m$
$mv = (M+m)V \Rightarrow V = 1.1 m/s$
$\frac{1}{2}(m+M)V^2 = \frac{1}{2}kA^2$
$A = \sqrt{\frac{(M+m)V^2}{k}} = 3.32\ cm$

Question 13:



0.10\,\text{g} of helium gas follows the process $1 \to 2 \to 3$ shown in figure. Find the value of T_1.

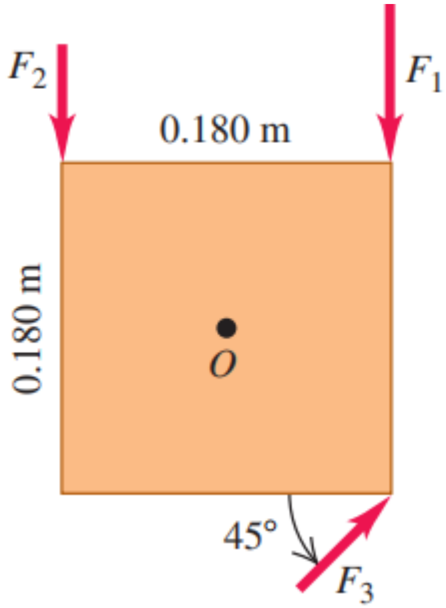
$T_2 = 2926K$
$T_3 = 2438K$
$V_1 = 1\times10^{-4}m^3$
$V_2 = 200cm^3$
$V_3 = 300cm^3$

$P_1 = 1atm$
$P_2 = 3atm$
$P_3 = 2atm$

$n = \frac{0.1}{4} = 0.025 mol$

$T_1 = \frac{P_1V_1}{nR}$
$= \frac{1.013\times10^5\times1\times10^{-4}}{0.025\times8.314} \approx 48.74K$

Question 14:



A square metal plate $0.180 \mathrm{~m}$ on each side is pivoted about an axis through point O at its center and perpendicular to the plate as shown in figure. Calculate the net torque about this axis due to the three forces shown in the figure if the magnitudes of the forces are $F_1 = 18.0 \mathrm{~N}$, $F_2 = 26.0 \mathrm{~N}$, and $F_3 = 14.0 \mathrm{~N}$. The plate and all forces are in the plane of the page.

A. $1.50 \mathrm{~N} \cdot \mathrm{m}$

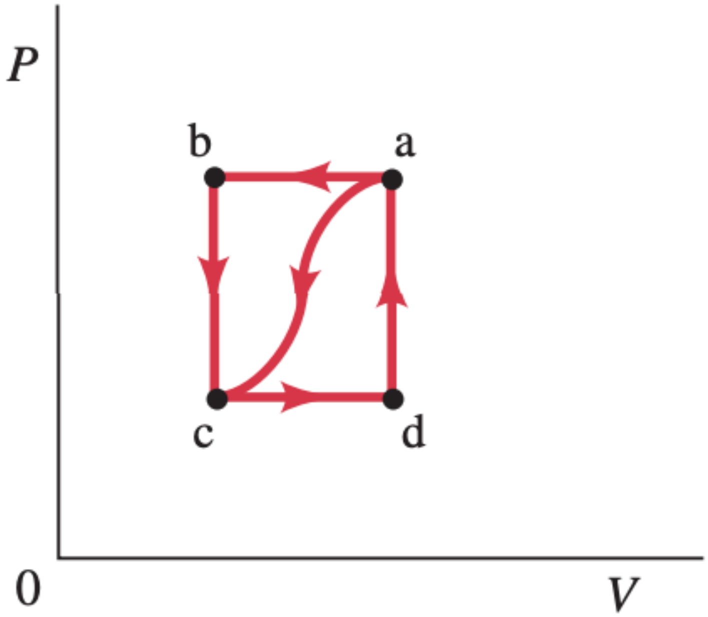
B. $2.50 \mathrm{~N} \cdot \mathrm{m}$

C. $5.00 \mathrm{~N} \cdot \mathrm{m}$

D. $4.50 \mathrm{~N} \cdot \mathrm{m}$

A

Question 15:



$W_{ac} = -35J$

$Q_{ac} = -175J$

$\Delta U_{ac} = Q - W = -140J$

$W_{abc} = -56J$

$\Delta U_{abc} = \Delta U_{ac} = -140J$

$\therefore\ Q_{abc} = -196J$

$\Delta U_{dc} = U_d - U_c = 42J$

When a gas is taken from a to c along the curved path in figure, the work done by the gas is $W = -35\,\mathrm{J}$ and the heat added to the gas is $Q = -175\,\mathrm{J}$. Along path abc, the work done by the gas is $W = -56\,\mathrm{J}$. (That is, $56\,\mathrm{J}$ of work is done on the gas.) $U_d - U_c = 42\,\mathrm{J}$. What is Q for path da?

$\Delta U_{da} = (U_c + \Delta U_{ac}) - (U_c + \Delta U_{dc})$

$= -182J$

$\therefore\ W_{da} = 0 \Rightarrow Q_{da} = -182J$

Question 16:

$D = 0.15m$

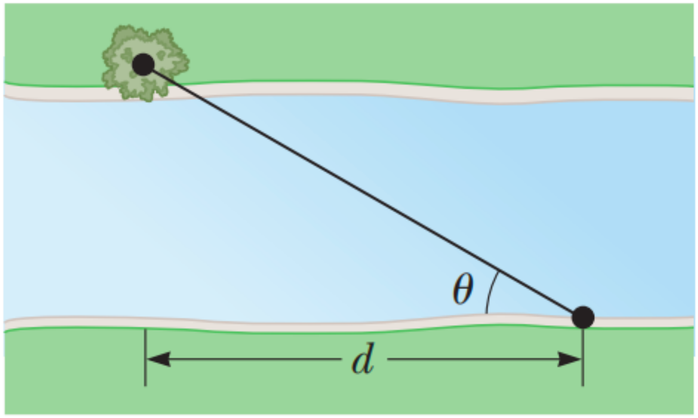
$v = 343m/s$

$f = \frac{v}{2L} \Rightarrow f = \frac{343}{2\times 0.15}$

$\approx 1143Hz$

You put your ear very near a $15\,\mathrm{cm}$-diameter seashell (figure). Estimate the frequency of the sound of the ocean.

Question 17:



A surveyor measures the distance across a straight river by the following method as shown in figure. Starting directly across from a tree on the opposite bank, she walks $d = 100\ \mathrm{m}$ along the riverbank to establish a baseline. Then she sights across to the tree. The angle from her baseline to the tree is $\theta = 35.0^\circ$. How wide is the river?

C

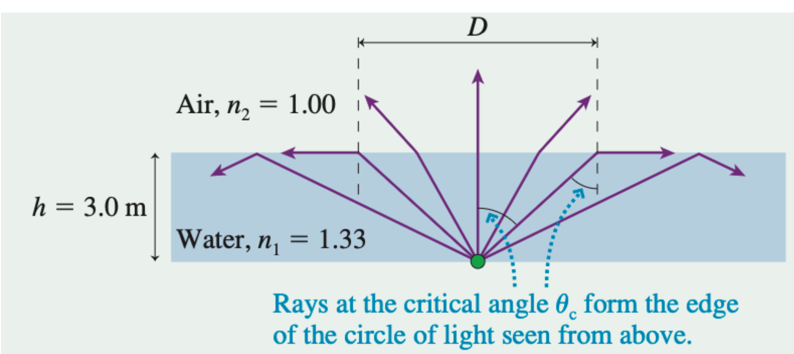
A. 24.0m

B. 35.0m

C. 70.0m

D. 65.0m

Question 18:



A lightbulb is set in the bottom of a 3.0m deep swimming pool. What is the diameter of the circle of light seen on the water's surface from above?

$$\sin\theta_c = \frac{n_2}{n_1} = \frac{1.00}{1.33}$$

$$\theta_c \approx 48.75^\circ$$

$$\sin\theta_c = \frac{\quad}{h}$$

$$r = h\sin\theta_c = 3 \times 0.7519 \approx 2.26m$$

$$D = 2r = 4.52m$$